**Original Article**

# Effect of Ingested Liquids on Color Change of Composite Resins

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**Abstract:**
**Objectives:** Color change of composite restorations is well known to dentists. However, the effect of commonly consumed drinks on discoloration of composite resins has yet to be determined. This study sought to assess the color change of a nanofilled (Premise) and a flowable composite resin (Premise flowable) following simulated consumption of tea, cola, iron drops and multivitamin syrup.
**Materials and Methods:** Forty disk-shaped specimens (7 mm in diameter and 2 mm thick) were fabricated from each composite resin. The baseline color values were measured according to the CIE L*a*b* system using digital imaging. The specimens of each restorative material were randomly divided into five groups (eight each) according to the storage media namely tea, cola, iron drops, multivitamin syrup or distilled water (control). The specimens were immersed in staining solutions for three hours daily over a 40-day test period. Following this, the color change values (ΔE*) were calculated. For statistical analyses, the color differences were analyzed using two-way ANOVA and Tukey's test ($P< 0.05$).
**Results:** There was no significant difference in ΔE* values between the two types of composite resins ($P>0.05$). In both composite materials, the difference among the solutions was not significant ($P>0.05$).
**Conclusion:** Under the tested experimental conditions, both restorative materials were susceptible to discoloration by all four staining solutions. The color change values were not related to the solution or the type of material used.
**Keywords:** Composite Resins; Tooth Discoloration; Color
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## INTRODUCTION

At present, various types of aesthetic restorative materials are widely used with different properties and colors. Composite resins are among the tooth-colored restorative materials of choice for many dentists due to their high acceptance by patients and their ability to bond to tooth structure, their excellent esthetic properties, favorable strength, relatively low cost (compared to ceramics) and application in both anterior and posterior teeth [1-3]. The success of composite restorations highly depends on the color stability of resin in long-term.

Perceptible discoloration of the restorative materials may compromise restoration esthetics, which is among the most common reasons for replacement of anterior composite resin restorations [1,3,4]. Both intrinsic and extrinsic factors may be responsible for the color change of composite restorations. Color change of the resin matrix itself or the matrix/fillerinterface, chemical discoloration related to the alteration or oxidation of amine catalyst, resin matrix structure and unreacted methacrylates due to incomplete polymerization comprise the intrinsic factors [4]. Extrinsic staining occurs as the result of adsorption and/or absorption of staining materials due to exposure to external sources [4]. The degree of color change varies from patient to patient based on oral hygiene status, nutritional habits, smoking status and consumption of different beverages [4].

Numerous studies have demonstrated the effect of staining solutions such as red wine, coffee, cola and tea on composite resins [5]. According to Ardu et al, in 2010, the degree of composite color change depends on the brand and structure of composite resin. Among the staining agents, red wine caused the highest color change followed by coffee, tea, orange juice, and cola [6]. Nasoohi and Ghaemi in 2013 found that color change of Filtek P60 and Z250 composite resins was clinically unacceptable and the degree of alteration was higher as the result of exposure to imported tea than the Iranian tea [7].

Ertas et al, in 2006 reported lower stainability of Filtek P60 and Z250 composite resins than nano-hybrid composites and Quadrant LC. Red wine had the highest staining potential in comparison with coffee, tea, cola, and water, respectively [8].

khatri and Nandlal in 2010 showed that the color change of conventional composites (TPH spectrum, Dentsply B1) was more severe than that of Ceram X B1 nanocomposite especially in coffee [9].

In a study by Mahdisiar et al, in 2014, three nanocomposites (Grandio, Z350XT and Herculate XRV Ultra) showed clinically unacceptable discoloration when immersed in coffee [10]. Composite resins are increasingly used in pediatric dentistry and only a few studies have evaluated the effect of commonly used beverages and medications by children particularly iron drop and multi-vitamin syrup on discoloration of composite resins. On the other hand, the degree of color change depends on the composition of materials [11]. Therefore, the purpose of this in vitro study was to assess the color change of nanofilled and flowable composite resins (Premise, Kerr, Orange, CA, USA) following exposure to tea, cola, iron drop and multivitamin syrup.

## MATERIALS AND METHODS
### Specimen preparation
This study had an in vitro experimental design. A2 color shades of a flowable composite resin (Premise, Kerr, Orange, CA, USA) and a nanofilled composite resin (Premise, Kerr, Orange, CA, USA) were used in this study (Table 1).

According to Curtin et al, in 2008 [12] 40 disk-shaped specimens were fabricated of each material (7 mm in diameter and 2 mm thick), using plastic molds. The molds containing composite resin were held between two glass slides, each covered with a transparent polyester strip (Mylar; Henry Schein, Melville, NY, USA), and the slides were gently pressed to remove excess material.

**Table 1.** Name, material type and manufacturer of the tested resin-based composites.

| Product | Material Type | Manufacturer | Lot No. |
|---|---|---|---|
| Premise Trimodal | Nanofill | Premise, Kerr, Orange, CA, USA | 290395 |
| Premise Flowable | Flowable | Premise, Kerr, Orange, CA, USA | 2893365 |

The top and bottom surfaces of each specimen were light-cured for 40 seconds using a conventional halogen light-curing unit (Optilux 401 Demetron, Kerr, Orange, CA, USA) with a light intensity of 500 mW/cm². The tip of the light guide was in contact with the cover glass during the light-polymerization process. After removing the specimens from the molds, they were stored in distilled water for 24 hours at 37°C for rehydration and completion of their polymerization. The top surfaces of all specimens were wet-polished with 800-, 1000, 1500-, and 2000-grit silicon carbide papers, consecutively.

### Staining process

Four types of liquids commonly consumed by children namely tea, cola, iron drops (Ferbolin, Shahredaru, Tehran, Iran) and multivitamin syrup (Minadex, Marfleet, England) were tested in the present study (Table 2). Eight samples were randomly selected from each material and immersed in each of the four staining solutions for three hours per day at 37°C over a 40-day test period [13]. Tea solution was prepared by immersing two tea bags (Ahmad tea Hashtgerd, Tehran, Iran), (2 × 2 g) into 300 mL of boiling distilled water for 10 minutes [8]. All the test solutions were refreshed daily prior to each test period. The distilled water group was considered as control. Following completion of the immersion time, the samples were rinsed under running distilled water and air-dried. Samples were then stored in distilled water at 37°C.

### Color testing

The samples were digitally photographed at baseline and after staining (Finepix S9600, Fuji, Tokyo, Japan) under standardized conditions against a black background (distance: 25 cm zoom: ×1). Daylight was blocked out and two 6500°K light sources were placed at 45-degree angles relative to the subject. The photographic procedure included a piece of gray card in the picture as a neutral reference object. Color casts were eliminated and image brightness was fine tuned using a standard image-editing program (Adobe Photoshop cs5, Adobe Systems Incorporated, San Jose, CA, USA) before the relevant color values were measured [14].

Values were recorded using the CIE (Commission International de l' Eclairage) L*a*b* color system [15].

In Photoshop software, the range of the mean L* (L [PM]) value is 0 to 255. The CIE L* value ranges from 0 to 100. A transformation can be done using the following formula:

$$L^* = L (PM) \times 100/255$$

The a* and b* values were transformed in the same manner. The Photoshop values range from 0 to 255, and the CIE L*a*b* values from -120 to +120.

The transformation formulas are as follows:

$$a^* = [a (PM) - 128] \times 240/255$$
$$b^* = [b (PM) - 128] \times 240/255$$

Where a (PM) and b (PM) are the Photoshop mean values of a* and b*, respectively [13].

The color differences or ΔE* between the two measurements were calculated as follows [15]:

**Table 2.** Staining solutions used in the study

| Product | Trade name | Manufacturer |
| --- | --- | --- |
| Tea | Ahmad Tea | Ahmad Tea Tehran, Hashtgerd, Iran |
| Cola | Coca-Cola | Khoshgovar Tehran Co., Qazvin, Iran |
| Iron drop | Ferbolin | Shahredaru, Tehran, Iran |
| Multivitamin syrup | Minadex | Seven Seas Health Care, Marfleet, Hull, England |

$$\Delta E^* = [\,(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2\,]^{\frac{1}{2}}$$

The $\Delta E^*$ values greater than or equal to 3.7 were considered as clinically-unacceptable color change that can be detected by the naked eye [15,16].

### Statistical analysis

Data were analyzed using SPSS version 16 software (SPSS Inc., Chicago, IL, USA). Descriptive statistics were shown as mean± standard deviation (SD). Two-way ANOVA was used to evaluate the effects of material type and staining solution on color change. Thus, subgroup analysis was performed with independent t-test, and Bonferroni correction was also applied.

### RESULTS

The mean and SD values of $\Delta L^*$, $\Delta a^*$, $\Delta b^*$ and $\Delta E^*$ for each material are listed in Table 3.

Distilled water caused no visible color change ($\Delta E < 3.7$). The color change values ($\Delta E^*$) of tea, cola and iron drops for flowable composite and nanofilled composite were higher than 3.7. According to the results of the two-way ANOVA, the interactions between all materials and staining solutions were significant (P=0.048). Subgroup analysis showed no significant differences between the composite resin materials for all staining solutions (P= 0.058).

### DISCUSSION

Color stability of tooth-colored restorations is of particular importance because of their aesthetics and reduction of additional cost due to frequent replacement.

In addition to the above, fewer treatment sessions for restoration replacement is a top priority in pediatric dentistry.

**Table 3.** The mean values and standard deviations of $\Delta L^*$, $\Delta a^*$, $\Delta b^*$ and $\Delta E^*$ for the staining solutions and distilled water

| Product | Nanofilled composite | Flowable composite | P value |
|---|---|---|---|
| **Tea** | | | |
| $\Delta L^*$ | -28.6±0.5 | -27.3±1.3 | 0.098 |
| $\Delta a^*$ | 6.6±0.5 | 6.2±0.4 | 0.114 |
| $\Delta b^*$ | 0.8±1.5 | 1.7±1.1 | 0.297 |
| $\Delta E^*$ | 29.4±0.5 | 28.1±1.2 | 0.073 |
| **Cola** | | | |
| $\Delta L^*$ | -1.4±0.4 | -1.9±0.4 | 0.085 |
| $\Delta a^*$ | 3.1±0.4 | 3.4±0.5 | 0.197 |
| $\Delta b^*$ | -0.7±1.3 | 0.9±0.4 | 0.058 |
| $\Delta E^*$ | 3.8±0.4 | 4.0±0.7 | 0.325 |
| **Iron drop** | | | |
| $\Delta L^*$ | -4.1±6.4 | -1.9±1.0 | - |
| $\Delta a^*$ | 3.3±0.5 | 3.2±0.3 | 0.814 |
| $\Delta b^*$ | 0.2±0.7 | 0.9±1.0 | 0.164 |
| $\Delta E^*$ | 5.9±5.8 | 4.0±0.5 | 0.614 |
| **Multivitamin syrup** | | | |
| $\Delta L^*$ | -1.6±0.5 | -1.7±0.4 | 0.974 |
| $\Delta a^*$ | 3.1±0.7 | 2.6±0.6 | - |
| $\Delta b^*$ | -0.2±1.2 | -0.3±0.8 | 0.849 |
| $\Delta E^*$ | 3.7±0.7 | 3.2±0.7 | 0.081 |
| **Distilled water** | | | |
| $\Delta L^*$ | -0.8±0.7 | -0.8±0.8 | - |
| $\Delta a^*$ | 0.2±0.4 | -0.2±0.2 | - |
| $\Delta b^*$ | -1.3±1.7 | -0.4±0.6 | - |
| $\Delta E^*$ | 2.0±1.4 | 1.1±0.7 | - |

This study sought to assess the staining effect of different staining solutions on the color change of two widely used composite resin materials in primary teeth.

Based on a study by Dozić et al, spectrophotometry and digital camera are the most reliable methods for determining the tooth color [17]. Spectrophotometer is a complex, expensive and technique-sensitive tool to determine the tooth color just in the surface. Thus, we used digital radiography for color measurements as an easier and reliable tool with optimal repeatability, sensitivity and objectivity. It provides quantitative data along with digital images [18,19].

Previous studies showed that validity and reliability of digital imaging were similar or even superior to those of spectrophotometry [18-21].

We chose CIE Lab system for measuring chromacity and recording color differences because this system is suitable for identification of small color changes and has some advantages namely repeatability, sensitivity and objectivity [22].

In our study, color-change values (ΔE) of tea, cola, and iron drops for flowable composite resin and color-change values of tea, cola, iron drops and multivitamin syrup for nanofilled composite resin were larger than 3.7 that can be detected with the naked eye [23]. Additionally, no significant difference in discoloration was noted between the tested composites. In accordance with our results, Ardu et al, in 2010 demonstrated that color change of Premise composite was clinically unacceptable after exposure to different staining solutions [6].

Nasoohi et al, in 2007 found no significant difference in color change between two different types of composites (Premise nanofiller and Point 4 microhybrid composite) after exposure to Iranian and imported tea [7].

In this regard, Mundim et al, in 2010 reported that although color change of composite resins with high filler content was lower than that of composite resins with lower filler content, this difference was not statistically significant [24]. Mazaheri et al, in 2013 showed that there was no difference in stainability of new nanofiller composite resins in comparison with microhybrid composite resins, but type of staining solution had a significant effect on color change [3]. Patel et al, in 2004 reported that the degree of color change was related to the type of staining solution used and did not depend on the type of composite resin [25]. Surface roughness, amount and size of filler particles and the physical, chemical and mechanical characteristics of resin matrix such as water sorption, hydrophilicity and the degree of conversion are the factors affecting composite resin stainability [23]. Nanofilled composite resins are made of two different particle sizes namely nanomer (individual and roughly spherical fillers) and nanocluster (loosely agglomerated collection of nanoparticles) that have several advantages namely low polymerization shrinkage, high mechanical properties, better gloss retention, less wear and control of transparency [9]. As stated by the manufacturer, Premise Trimodal is a nano-composite composed of three different types of filler components namely non-agglomerated discrete silica nanoparticles, barium glass, and pre-polymerized filler. It can be expected that nano-composites with a smaller particle size will have a smoother surface and will retain less surface stains [13, 26]. However, in the current study, these differences were not evident, as no significant difference in discoloration was noted between the tested composites. This could be due to the similar filler particles and the fact that both composite resins were nanofilled.

Generally, all staining agents stained all composite resin materials; tea produced the most severe stain and multivitamin syrup the least.

The color change values in all solutions were not significantly different between the two composites (P>0.05) (Table 3). This finding is somehow in accord with the results of previous studies by Nasoohi et al, in 2011 [23] Yousef and Naga in 2012 [27] and Fontes et al, in 2009 [28]. Ertas et al, in 2006 [8] and Ardu et al, in 2010 [6] showed that tea produced significant discoloration in some types of composite resins that is inconsistent with our results. It could be explained by the difference in the type of tested composite resins, the duration of exposure to the various staining solutions and the type of used staining solution in each study. Other factors may play more important roles in the composite resin satiability than the type of staining solution. In accordance with the results of studies by Ertas et al, in 2006 [8] and Zajkani et al, in 2013 [4], our results showed that tea caused more severe color change than cola. Previous findings revealed that yellow colorants in tea have high polarity. Discoloration by tea is due to the adsorption of polar colorants onto the surface of composite resin materials, which causes more discoloration than cola [23].

Based on a study by Um and Ruyter in 1991, although the low pH of cola may affect the surface integrity of the material and soften the matrix, the lack of yellow colorant in cola may be the reason why it did not cause a discoloration similar to tea [29]. No statistically significant difference was found between the samples immersed in iron drop and multivitamin syrup. It could be due to the difference in their viscosity, presence of other compounds and iron content (25 mg/1cc vs. 12 mg/1cc in multivitamin syrup). In agreement with other studies [8,10], when composite resins were immersed in water, the color differences were imperceptible and clinically acceptable. Our obtained results and those of other studies revealed that water sorption alone was not able to cause a significant color change in composite resins [13,30].

Although the interaction effect was significant, this effect was quantitative and not qualitative and no significant differences were found between the composite resin materials in the staining solutions.

## CONCLUSION

Based on our study results, there was no difference in the degree of discoloration between the two types of composite resins. The discoloration values did not depend on the type of staining solution.

## ACKNOWLEDGEMENT

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